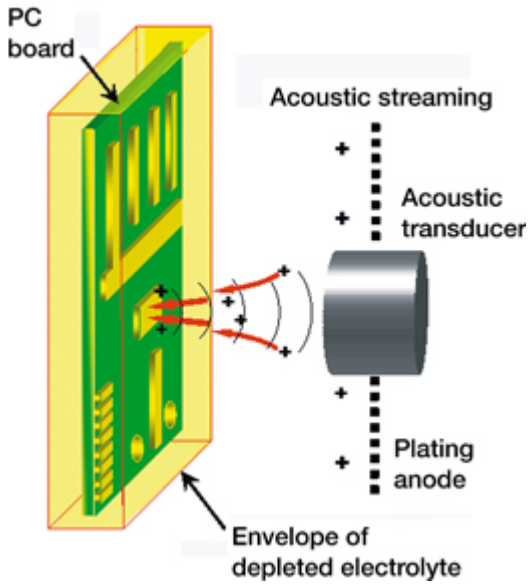
Electrochemical Processes Enhanced by Acoustic Liquid Manipulation

Acoustic liquid manipulation is a family of techniques that employ the nonlinear acoustic effects of acoustic radiation pressure and acoustic streaming to manipulate the behavior of liquids. Researchers at the NASA Glenn Research Center are exploring new methods of manipulating liquids for a variety of space applications, and we have found that acoustic techniques may also be used in the normal Earth gravity environment to enhance the performance of existing fluid processes. Working in concert with the NASA Commercial Technology Office, the Great Lakes Industrial Technology Center, and Alchemitron Corporation (Elgin, IL), researchers at Glenn have applied nonlinear acoustic principles to industrial applications.

Collaborating with Alchemitron Corporation, we have adapted the devices to create acoustic streaming in a conventional electroplating process. As shown in the figure, an acoustic transducer is immersed in a tank of electroplating electrolyte. In this case, the process involves the selective gold plating of electronic circuit boards.



Acoustic streaming transducers can improve the controllability of an electroplating system, possibly eliminating the need for masking operations.

Long description. Enhanced deposition of plating metal by forced removal of exhausted electrolyte surface layers is aided by acoustical streaming. Illustration shows PC board, acoustic streaming, acoustic transducer, plating anode, and envelope of depleted electrolyte.

Normally the selective plating process would involve the use of masking tapes or masking coatings to distinguish the surface areas selected to be plated and to protect the nonselected areas. The masking process is the most labor- and tooling-intensive aspect of the plating process, and the disposable masking materials often become a substantial

source of toxic waste. Substantial cost, health, and environmental issues motivate us to eliminate the masking process.

In a normal electroplating process, an electric field is used to deposit a metal onto a target part. The plating process is often impeded by the depletion of the electrolyte in the immediate vicinity of the part. The normal solution is to agitate the bath to eliminate the depleted layer that envelopes the part.

In the acoustically enhanced process, the bath is left quiescent and an envelope of depleted solution is allowed to form. We treat this depleted envelope as a virtual mask and use acoustic streaming to provide a low-speed liquid jet to penetrate the envelope with fresh "undepleted" electrolyte. The plating rate in the area where the acoustic beam impinges on the target is dramatically higher. Deposits are at least 10 times higher than in the area outside the beam. By careful manipulation and coordination of the electric current and the acoustically driven stream, we can control the shape, size, and deposition rate of the plated area.

Ongoing development and refinement of the process is expected to provide a viable maskless method of electroplating. In the future, we expect to employ acoustic phased-array techniques to provide electronic beam steering and focusing. Such a system will provide selective plating by raster scanning the acoustic beam to "paint out" preprogrammed patterns. This technology was recently patented and is available for licensing by commercial users.

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